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Published in:
Lasers and Electro-Optics Society

Link to article, DOI:
10.1109/LEOS.2000.890783

Publication date:
2000

Document Version
Publisher's PDF, also known as Version of record

Reduction of interferometric crosstalk induced penalty using a saturated semiconductor optical amplifier

Fenghai Liu, Xueyan Zheng, Henrik N. Poulsen, David Wolfson, Palle Jeppesen
Research Center COM, Technical University of Denmark, Building 349, Lyngby, DK-2800, Denmark
Telephone: +45-45253845, Fax: +45-45936581, Email: lf@com.dtu.dk

Introduction

WDM networks have been installed on a global scale to satisfy the ever-increasing demand of communication capacity. As the number of wavelength increases, the interferometric crosstalk is becoming critical. Strong requirements on crosstalk are imposed to the components used in large-scale transparent optical networks.[1,2]

Components with low crosstalk are important, but other effective techniques to suppress the impact of crosstalk are also needed. Several techniques can be used for this purpose, e.g., using a gain saturated laser diode amplifier [3], wavelength conversion based on cross-phase-modulation [4] or cross-gain-modulation [5,6] in semiconductor optical amplifiers (SOA).

The gain saturated laser diode amplifier needs a filter to suppress the lasing signal from the diode and it is limited to low bit-rate. To suppress the crosstalk, wavelength conversion is not always necessary. For instance, a tunable source is needed to track the wavelength of input signal in the wavelength converter in order to keep the same wavelength for the input and output signals, which is complex and expensive. SOA has a fast gain saturation, which can be used to suppress the fluctuation on the optical amplitude. A holding CW light counter-propagating with the input signal is used to overcome waveform distortion in the saturated SOA. This scheme avoids wavelength conversion. Since the SOA is of simple structure and bit-rate transparent at high speed, it is promising in reduction of crosstalk impact in transparent optical networks.

Experiment and results

Fig.1 shows the experimental set-up to demonstrate the capability of reducing the crosstalk induced power penalty using a saturated SOA.

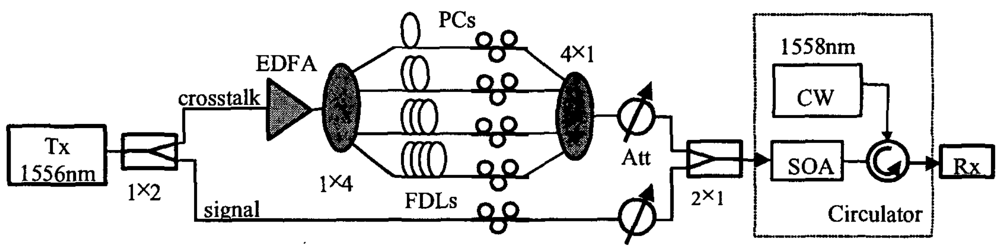

Fig.1. Experimental set-up. Tx: transmitter; 1×2 and 2×1: 3dB coupler; 1×4 and 4×1: star coupler; PC: polarisation controller; FDL: fibre delay line; Rx: PIN receiver.

The power from the transmitter is split into two parts; one part serves as signal, and the other part as crosstalk. The crosstalk part is amplified by an EDFA and further divided into four parts using a 1×4 star coupler in order to simulate four crosstalk terms. The four crosstalk terms are de-correlated by different lengths of fibre delay lines, aligned in the same polarisation state as the signal for maximum impact using polarisation controllers and combined again using a 4×1 star coupler. The crosstalk contributions are attenuated and combined with the signal. Another attenuator is used to control the power into the saturated SOA. Bit error rate (BER) curves are measured with and without the SOA before the PIN receiver. Optimal decision threshold is used in the BER measurement.

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In order to overcome the waveform distortion when the SOA is saturated, a holding light in CW operation at 1558 nm is injected into the SOA through a circulator, counter-propagating with the input signal, as shown in a dashed frame in Fig.1.

The transfer characteristic of the saturated SOA is shown in Fig.2 when the power of CW light is 6.1 dBm. From the transfer characteristic, it can be found that the SOA is highly saturated when the input power is higher than 0 dBm. The average input power into the SOA is 1 dBm in our experiment in order to suppress the crosstalk-signal beat noise on the "1" level.

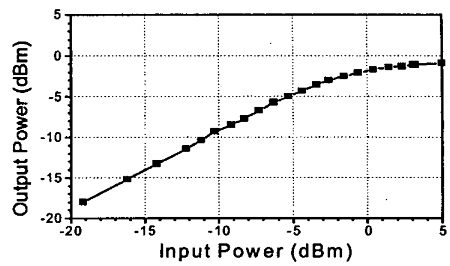
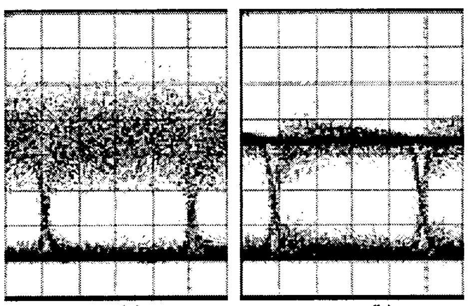


Fig.2. Transfer characteristic of the SOA saturated by a CW light of 6.1dBm

Since SOA is bit-rate transparent, the saturated SOA is used to reduce the crosstalk impact at both 2.5Gb/s and 10Gb/s. Fig.3 shows the eye-diagrams with -15 dB crosstalk before (a) and after (b) the SOA at 2.5Gb/s. A clearer eye can be seen after using the SOA. Fig.4 shows the penalty curves versus relative crosstalk power at 10 Gb/s. A 4 dB more crosstalk power can be tolerated at 1 dB penalty when the saturated SOA is used.

Using saturated SOA will significantly relax the crosstalk requirement on the components used in cascade in transparent optical networks where interferometric crosstalk accumulates.



(a) (b)

Fig.3. Eye-diagrams before (a) and after SOA. Time scale: 100ps/div

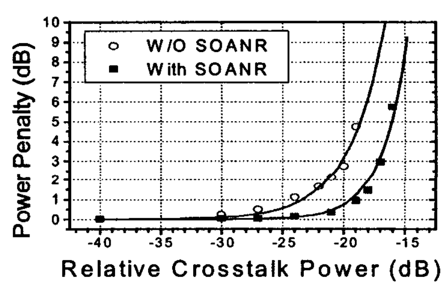


Fig.4. Penalty vs. relative crosstalk power with and without SOA at 10Gb/s

Conclusion

We successfully demonstrated that a simple saturated SOA could be used to reduce the impact from the interferometric crosstalk at 2.5Gb/s and 10Gb/s. It is shown that 4 dB more crosstalk power can be tolerated at 1 dB penalty by using the SOA. This will greatly reduce the crosstalk requirement on components, especially these used in cascade in large-scale transparent optical networks.

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